



DRAFT INTERNATIONAL STANDARD ISO/DIS 15865

ISO/TC 20/SC 14

Secretariat: **ANSI**

Voting begins on
2002-08-01

Voting terminates on
2003-01-01

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION •

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Foreword

Introduction

This International Standard applies to systems and products used in flight or for ground support, and to products at all levels in a product tree. It applies to systems and products consisting of hardware, software, facilities, materials, methods, processes, or procedures, or any combination of these.

1 Scope

This International Standard establishes common rules for assessing the qualification of space systems and products used in space systems against their technical specifications. It establishes a basis for determining system or product readiness for any stage of the life cycle. This includes, for example, readiness for development, manufacture, test, operation, modification, or disposal.

2 Normative references

4 Objectives and principles

4.1 Linkage to other international standards

This International Standard should be used in addition to the provisions of International Standards ISO 9001, ISO 14300-1, ISO 14300-2, and ISO 14620-1, which relate to qualification assessment of SS items against the customer's functional and technical requirements.

4.2 Objectives

The qualification process should ensure achieving the following objectives:

- a) ensuring that the product meets specified requirements;
- b) ensuring that the product matches production drawings;
- c) confirming product operability after tests, verifications, flight tests, and landing;
- d) ensuring the safety of SS products in accordance with ISO 14620-1;
- e) ensuring the required quality level to SS customers;
- f) assisting customers in selection of proper SS products and services on a competitive basis;
- g) creating terms and conditions favourable for SS insurance;
- h) assuring that the products are able to comply with the disposal requirements.

4.3 Principles

SS qualification assessment should be based on the following principles:

- a) proper definition of the requirements to be verified by qualification;
- b) use of only approved items for qualification assessment with deviations justified and agreed upon by the customer and the supplier in accordance with contractual provisions;
- c) use of all appropriate information obtained in all phases of the program;
- d) sequential analysis of the results obtained during all phases and levels of the program, taking into account the results obtained in the previous phase and other levels as appropriate;
- e) lowering the uncertainty of the assessment as the additional information becomes available, particularly when the development transitions from one phase to the next, or when it proceeds to the next level;
- f) proper planning of the qualification assessment;
- g) early detection of problems potentially capable of impacting cost, schedule, safety, or quality of the program (or any combination of these) and implementation of corrective action with customer approval.
- h) tailoring of the execution of the qualification assessment and its precision during the item life cycle.

The customer should analyse the past performance of his own potential suppliers and sue this performance as an element of supplier selection criteria, and he should issue the TS to these suppliers.

4.4 General requirements and recommendations

A supplier can develop a space system item either in compliance with a customer–supplier contract, without a contract when there is an expected market for the item after development is complete. In either case, a supplier acts as a customer towards its own suppliers.

When this International Standard is made part of a contractual agreement between a customer and supplier, the agreement shall establish the customer and supplier responsibilities and authorities, as appropriate, concerning the

Items to be qualified at any level may include any of the following types: hardware, software, facility, material, processes, methods, and procedures.

4.6 Design Justification Data File (DJDF)

The DJDF is aimed at integration of all information confirming the design compliance to specified requirements. It provides a record of the values of specified technical characteristics that are subject to qualification. The DJDF includes data from all qualification assessments obtained during all phases of the project. It is developed under the supplier's responsibility and authority during design, production, qualification, operation, and disposal. The DJDF integrates information from qualification process documents and is based on functional and technical characteristics that are subject to qualification.

Each characteristic recorded in the DJDF should be categorized as major or minor. Major characteristics should be assessed periodically to detect trends. All measurement results are maintained in the DJDF. For characteristics displaying uncertainties or deviations, their values are entered into the DJDF prior to and after corrective measures are taken.

NOTE The purpose of trend detection is to enable early application of corrective actions that are necessary to control a characteristic and maintain its value within a specified range.

- h) the necessity to solve complicated scientific and technical problems in a short fixed time due to external factors (e.g., to enable launch on a fixed date or during a short launch window).

The SS qualification process utilises documentation and other results of activities performed during phases 0, A, B, C, D, E, and F, that are specified in ISO 14300-1, 4.4.2. In the general case these results include:

- i) issue and co-ordination of the TS;
- j) design;
- k) working documentation;
- l) production set-up and prototype manufacturing results;
- m) ground test results;

In addition, the following data may contribute to the process:

- n) flight-test results;
- o) results of full-scale production and operation.

5.1.3 Criteria

The following criteria shall be verified during qualification assessment of the SS or SS item.

- a) The system is completed and its documentation is approved.
- b) Requirements traceability is established.
- c) All operational constraints and environment load limitations are specified.
- d) All the assumptions inherent in the design of the system are defined.

5.2 Arrangement of work

5.2.1 Principles for selection of an organisation or a group of specialists for qualification reviews

The following principles should be followed when selecting any organisation or group of specialists for qualification assessment review.

- a) The candidates should not be administratively or materially dependent on the assessment results;
- b) The candidates should be competent, which can be estimated by the frequency of expert assessments accomplished, practical confirmation of their assessments, and the extent to which their assessment recommendations were followed.

The following are examples of sources of suitable personnel for performing qualification assessment review (in order of increasing level of independence):

- c) for an internal review, any part of the suppliers organisation;
- d) any part of the customer organisation;
- e) specially established commissions comprised of skilled experts from the customer '

Table 1 — Descriptions of applied methods

ID	Name of method	Description
1	Analysis	Determination of essential qualities, performance, and limitations of an item by cognitive or computational methods.
2	Acceptance tests	Tests and verifications performed during product acceptance, including waiver and input control.
3	Estimation tests	Tests for detailed estimation of item capabilities.
4	Qualification tests	Tests for confirmation of meeting TS requirements, including safety factors.
5	Delta-qualification method	Specific tests of a part of an item in a limited area in which the loads and environment have changed (due to modification, use, etc.).
6	Qualification by similarity	Method of qualification of a new item based on the qualification of similar items in the past.
7	Quality system certification	A determination that the supplier's production process can reliably produce an item within specified quality limits.
8	Inspection	customer's planned or unplanned verification of the work performed by the supplier.
9	Review	Systematic examination of items for the purpose of assessing the results obtained at a given time in the project; conducted by persons not themselves responsible for the project.

Selection of the applied methods and their level of detail is determined by a number of factors including, for example: the qualification tasks to be accomplished, available prior information, project innovation, risk; product tree level; life cycle phase; item reliability, lot size, and supplier's experience. Methods resulting in quantitative

5.3.2 Activities on product definition during phases O – C

During these phases the following actions should be performed:

a) analysis of:

- 1) the TS for a product and its components (including analysis of their conformance to the advanced requirements);
- 2) justification of redundancy and reserves;
- 3) contingency plans intended to overcome hazardous situations;
- 4) single-points-of-failure;
- 5) critical items and their reliability;
- 6) primary reliability problems requiring special attention during subsequent development and test;

b) assessment of:

- 1) technical decisions and their rationale from the viewpoint of the specified reliability and safety requirements of the product and its components ;
- 2) feasibility of advanced requirements for items, systems, and components;
- 3) the proper selection of components, including EEE;
- 4) the experience obtained during the development of similar products and prototypes (including foreign items);
- 5) the application of qualification by similarity ;
- 6) compliance with reliability and safety requirements;
- 7) the implementation of the recommendations that resulted from reliability analysis (summary data on failures and associated corrective actions);
- 8) the manner in which reliability and quality assurance requirements are satisfied during the manufacturing process (including problems of run time, increased loads and severe conditions of routine hot tests, and other tests requiring additional resources);
- 9) the completeness and adequacy of assurance plans for
 - i) reliability,
 - ii) safety,
 - iii) ground testing, and
 - iv) qualification assessment.

5.3.3 Design review

In accordance with ISO 14300-1, design reviews are held at various points in the life cycle. At each of these cycles, a group of experts, representing all of the relevant disciplines should be formed to participate in the review.

NOTE Each review is a critical verification with the participation of competent specialists in the appropriate disciplines and under the leadership of a person whose activity is not directly connected with the organisation responsible for the project or the program. Information and justification on the activities completed are reviewed by the experts in such activities.

The experts' aim should be to facilitate:

- i) making a decision on whether the technical elements meet the contractual requirements and the aims of the phase under review;
- j) taking corrective and preventive actions, or both, in case of non-conformances or insufficiency;
- k) making a decision on transition to the next phase.

5.3.4 Design verification

Design verification should be performed to make sure that the output of a phase complies with the specified requirements. Design verification actions shall be documented.

5.3.5 Qualification assessment during updating of production technologies

At this phase of qualification assessment the following issues should be addressed:

- a) general design and technological assessment of component characteristics (i.e., feasibility, conceptual technological solutions);
- b) applied materials assessment (list of structural materials, including new materials and their basic physical, mechanical, chemical, and technological properties);
- c) problems of supplying advanced materials to production enterprises;
- d) decisions on occupational safety and health, fire-and-explosion safety, toxicity, environmental safety, and industrial sanitation in the processing of selected materials and their wastes under industrial conditions;
- e) analysis of recommendations on utilisation of worn or failed items; industrial waste utilisation or elimination considering requirements for personnel health and environment protection;

- 4) construction or modification of production and test facilities;
- 5) training of personnel for new kinds of activities.

5.3.6 Qualification assessment during ground tests

5.3.6.1 Anticipated activities

Required input data for initiation of activities are described in section 5.3.1.

During ground testing the following actions should be planned:

- a) analysis of:
 - 1) the extent to which GTP requirements were met in item and component testing (or analogue and prototype testing in the case of qualification by similarity);
 - 2) the status of GTP implementation for SS product and its elements;
 - 3) the status of reliability program implementation for SS elements and components;
 - 4) final test reports for SS components and subsystems (submitted by suppliers who conducted the tests).
 - 5) independent assessments conducted the customer's request;
 - 6) results of flight tests conducted at the production facility;
 - 7) developer's reports on elimination of failures and non-conformances detected during tests;
- b) assessment of:
 - 1) ground test results;
 - 2) implementation of the expert commission's recommendations;
 - 3) the conformance of technical characteristics to the TS requirements based on test results;
 - 4) acceptance inspection, run time, and modes of test items and their components designated for flight tests.

5.3.6.2 Development of ground test plan (GTP) for SS items and their elements

Input data include non-conformances detected during GTP implementation, in addition to those specified in 5.3.1.

The following actions should be performed in each phase:

- a) assessment of:
 - 1) compliance with the requirements provided by standards and functional and technical specifications on development for SS items and its components at each phase;
 - 2) completeness of the verification of technical characteristics as specified in the TS for the item and its components;
 - 3) appropriateness of the GTP to the item (and its component);
 - 4) adequacy of mock-ups for different kinds of ground tests;
 - 5) fidelity of ground tests in duplicating actual operational conditions;

- 6) completeness of interface tests of integrated systems;
- b) analysis of:
 - 1) distribution of qualification assessment in the different phases and levels;
 - 2) production readiness;
 - 3) emergency test plans in case of accident and hazardous situations;
 - 4) flight dynamics testing and dynamic characteristic correction programs;
 - 5) extent to which flight test problems might be solved in ground tests;
 - 6) plans for testing of safety margins (for reserve assessment) and tests of resources;
 - 7) verification of implementation of recommendations set forth in review reports;
 - 8) verification of qualification by similarity and the data obtained from analogue and prototype testing.

5.3.6.3 Test assessment

All necessary and sufficient tests should be performed at each phase or level for the purpose of:

- a) verification of specified technical characteristics of a product;
- b) verification of a product's functional characteristics;
- c) obtaining data for the DJDF.

- h) prior to the tests to ensure that adequate resources, procedures, and materials are available;
- i) after the tests to determine test conformance (non-conformance) to the test procedures;

A review of the results obtained should be documented.

5.3.7 Flight tests

The following analyses and assessments should be performed:

- a) analysis of:
 - 1) reports of developers on final elimination of non-conformances detected during past flight tests, as appropriate;
 - 2) reports of the developers on product and component modifications;
 - 3) developers' reports on the effectiveness of corrective actions;
 - 4) any changes in items and components;
 - 5) the modified item ground testing;
 - 6) additional documents on readiness of the next item for flight tests including results and recommendations from previous ground and flight tests, as appropriate;
 - 7) readiness of the next item for flight test, including its acceptance test results and the elimination of detected non-conformances;
 - 8) expert commission and developing organisation review reports authorising the next item for flight test or reflight;
- b) assessment of:
 - 1) the implementation of recommendations of experts for correction of failures detected during previous ground and flight tests;
 - 2) TS requirements implementation.

The flight test qualification process is completed by:

- c) a report issued by the organisation responsible for flight tests after the tests are completed; and
- d) by a decision to initiate phase E, utilisation.

Simultaneously, preparations are made to enter full-scale production of the item, as appropriate.

5.3.8 Production

At the start of this phase (phase D) the following tasks should be performed:

- a) establishment of parameters to control the stability of technological processes;
- b) establishment of a process to maintain traceability of product technical characteristics during acceptance inspection, acceptance tests, and operation;
- c) analysis of detected failures and non-conformances and effectiveness of actions to eliminate them;

- d) analysis of product modifications, including assessment of their impact on:
 - 1) cost, schedule, and risk, and
 - 2) the need for re-qualification assessment;
- e) analysis of the adequacy and effectiveness of modifications intended to increase reliability;
- f) analysis of the supplier's documentation on the elimination of any non-conformance;
- g) analysis of adequacy of the inspection process for critical items;

Performing the tasks previously listed above utilises:

- h) technical review;
- i) qualification assessments of specified technical characteristics;
- j) sampling to assess the current technical characteristics;
- k) analysis of the causes of failures and non-conformances;
- l) analysis of the effectiveness of actions taken to eliminate the non-conformances.

5.3.9 Software qualification assessment

In the process of software qualification assessment, analysis of the following should be performed:

- a) optimisation of algorithms, data formats, and the command system configuration;
- b) software algorithms;
- c) description of the mathematical model of the system and modelling results;
- d) list of software algorithm modules;
- e) memory, processor, and data transfer requirements for execution of algorithms;
- f) input language;
- g) software operational documentation;
- h) list of functional and service modules;
- i) dialogue tables and languages (for interactive systems);
- j) input and output data array structure;
- k) data support algorithms;
- l) the software development process;
- m) the library of test algorithms;
- n) functional block-diagrams and timing diagrams of software operation in all operational modes.

5.3.10 Configuration aspects

All design changes and modifications should be identified, documented, verified, and approved by authorised

Annex A (informative)

Contents of the DJP

The DJP should contain:

- a) defined values of the technical characteristics to be assess at teach phase of the product life cycle and each level of the product tree as defined in the TS;
- b) a list of tests and verifications, stating the purpose, description, and composition of the item under test, together with justification of any deviations from the nominal configuration (if applicable);
- c) the characteristics of assessment methods, assessment sequence, equipment used and their parameters, models, software, measurements, and the methods for processing results;
- d) acceptance criteria;
- e) sequence of corrective actions when a negative result is obtained;
- f) means and frequency requirements of equipment calibration, operator training plan, and the periodicity of operator qualification examination;
- g) list of reporting documentation for each phase and level;

- f) The DJDF enables an evaluation of the validity and the completeness of the justification and supports decisions on design qualification of the product of interest. It includes the results of qualification test analysis and assures that any product produced in conformity with the qualified design meets the needs of the customer expressed in the TS and that its design is feasible.

Annex C (informative)

Contents of the DJDF

The DJDF should have the organisation and contents listed in this Annex:

Part 1: Using an agreed-to format facilitates access to information including:

- a) the DJDF reference;
- b) the DJP reference;
- c) a list of each requirement in the TS;
- d) each requirement broken down into its identified characteristics;
- e) those DJDF components that facilitate the satisfaction of requirements at the negotiated visibility level;
- f) the documents that support justification (study reports, calculation sheets, test reports, etc.), indicating their validity with respect to the TS and the DJDF (or both);
- g) an overview of the justification obtained for each requirement, including any significant findings.

Part 2: A summary of all justifications, including:

- a) specified items and commitments which have not been honoured, along with proposed corrective actions and associated timetable;
- b) significant problems;
- c) justification remaining to be completed;
- d) analysis of justification either not provided or insufficiently established and the associated risks;
- e) margins with respect to required performance (if required for the justification);
- f) means of resolution for unresolved critical items;
- g) status of justification, relative to the DJP.

The justification of a particular requirement may be needed after special sequential tasks are carried out. In such cases, an additional document should be called for in the DJP and should be produced when needed. This document should compile all justification information on the relevant requirement.

NOTE This situation arises when the product design approaches the limits of requirements related to life cycles and associate environment conditions (high technical risk).

The following information should be included in the DJDF for all characteristics and should be presented in the form of a matrix, known as the qualification matrix:

- a) name of characteristic;

- b) specified quantitative or qualitative value(s) of the characteristic;
- c) conditions under which the characteristic values or behaviour are required;
- d) the characteristic value or behaviour obtained during qualification;
- e) summary of the means used to obtain the values or behaviour measured;
- f) anomalies encountered during any qualification assessment and how they might affect the interpretation of results;
- g) assessment of the qualification results specifically, conformance to the values in b) and c) above;
- h) results of analysis or registered deviations or discrepancies;
- i) correction and preventive actions (if necessary);
- j) complete reference information for documents or data supporting the justification and other information contained in the DJDF.

Sources of data for the DJDF should include data created during all phases of the program.

